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ABSTRACT

The five papers in this set describe a research program designed to examine how an intended science curriculum, as described in policy documents and textbooks, is interpreted by teachers and adapted to an established pattern of classroom functioning embodied in what is called a "functional paradigm." The overall objective of the research is to explore the value of the notion of functional paradigms, describe prevailing functional paradigms in secondary science teaching, and show how such paradigms establish the boundaries of classroom functioning and influence the interpretation of curriculum. The first paper in the set outlines the theoretical framework and describes the data base. This is followed by papers on three major substantive areas derived from the analysis: (1) teacher repertoires; (2) orchestration of the setting; and (3) content coverage and evaluation. Finally, a more general outline is given of what seems to be a dominant and a secondary paradigm for science teaching. The dominant paradigm is based on the primacy of teaching content under a whole class setting. The secondary paradigm appears to be based more on the idea of science as process and requires some modification of the dominant pattern of classroom behavior. (CW)

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# CURRICULUM TRANSLATION IN SECONDARY SCHOOL SCIENCE
# AN ANALYSIS OF TEACHER FUNCTIONAL PARADIGMS

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# I THEORETICAL BACKGROUND AND DATA SOURCES

## Introduction

The five papers in this set describe a research program designed to examine how science curriculum is interpreted by teachers and adapted to an established pattern of classroom functioning embodied in what is called a "functional paradigm." The underlying notion of a functional paradigm is derived from Kuhn's original work and from Imershein's extension of the ideas of paradigm and paradigm shift to organizational behavior. The overall objective of the research is to explore the value of the notion of functional paradigms, describe prevailing functional paradigms in secondary science teaching and show how such paradigms establish the boundaries of classroom functioning and influence the interpretation of curriculum.

The data base for the study consists of document analysis and interviews, along with some 250 hours direct observations in 23 secondary science classrooms. The data were analyzed by an iterative process of locating recurring themes in the observation transcripts, using these to derive broad categories under which interpretive accounts could be prepared, and elaborating or modifying these accounts from the iterview and documentary data.

This introductory paper outlines the theoretical framework and describes the data base. This is followed by papers on three major substantive areas derived from the analysis; teacher repertoires, orchestration of the setting, and evaluation. Finally, a more general outline is given of what seems to be a dominant and a secondary paradigm for science teaching. The dominant paradigm is based on the primacy of teaching content under a whole class setting. The secondary paradigm appears to be based more on the idea of science as process, and requires some modification of the dominant pattern of classroom behavior.

**Functional Paradigms in Teaching**

At the most global level our research is based on the concept that individuals act on the basis of the interpretations they place on the objects and events within a particular setting. This concept is not new, of course, as it forms the basis for schools of thought such as symbolic interactionism in sociology and personal construct theory in social psychology. Beyond using this basic concept, however, the research program owes relatively little to these schools of thought. Instead, a second point of departure is used, based on the work of Kuhn (1970) in the natural sciences, an extension of Kuhn's ideas to social organizations as proposed by Imershein (1977), and a specific application to teaching by one of the authors (Crocker, 1983).

Kuhn's well known thesis is that, rather than advancing in an orderly fashion, science proceeds through periods of relatively stable "puzzle solving" activity followed by periods of instability and eventual revolution. During the stable or "normal science" period, scientists in a field operate under a shared paradigm, which establishes the boundaries of a field of investigation, determines the questions asked and the methods of investigation used, and forms the basis for interpretation of the results. Even as new evidence accumulates which is not readily accounted for by the prevailing paradigm, the tendency is to attempt to salvage rather than to abandon the paradigm. Paradigms are abandoned only when contrary evidence becomes overwhelming, and when alternative paradigms become available. Unstable periods occur when paradigms begin to be called into question In Kuhn's analysis, revolutionary changes in science correspond to periods of paradigm shift, where the entire community must learn to function under new theoretical premises, consider entirely new questions, or use revolutionary different instruments or methods.

An important extension of these ideas to social systems has been made by Imershein (1977). Imershein's thesis is that members of a social organization can be considered to operate under a shared paradigm, in a manner analogous to that of a community of scientists. The prevailing paradigm sets the rules for the range of behaviors considered acceptable and

the kinds of activities engaged in by the members of the organization. When faced with unfamiliar or problematic situations, members of an organization first attempt to resolve the situation using the existing paradigm. In particular, problems are solved by moving by analogy from a familiar application or "exemplar" to the new application. It is only when this form of problem solving breaks down that pressures build to reconsider the prevailing paradigm. Often, such pressures become overwhelming, leading to instability in the organization, before a revolutionary change occurs, which resolves the situation but which, in turn, creates another round in the cycle of stability and revolution. Imershein illustrates this thesis with an example of organizational change in health care delivery services. Comparable examples may be found in the reaction of labour unions to technological change, lawyers to constitutional change, or religious groups to scientific developments which lead to moral dilemmas.

In our case, the concern is specifically with classroom teaching, particularly with how teachers interpret the curriculum and translate this curriculum into classroom practices. Crocker has already applied the notions of paradigm and paradigm shift to the study of teaching (Crocker, 1979; 1983; 1984; 1986). The term "functional paradigm" has been used to convey the idea that teacher paradigms are likely to be grounded in practical matters rather than in theory as is typically the case in the natural sciences. Paradigms in teaching may be said to take the form of shared practical knowledge, derived from common interpretations of the features of the setting in which a particular group of teachers function. The theoretical significance of our research lies in the ability to find data which can help elaborate the concept of functional paradigms, identify the salient characteristics of the paradigm (or paradigms, for there may be more than one extant) of a particular group of teachers.

For purposes of the study the group of interest consists of science teachers at the junior and senior secondary school levels, although, in practice, the sample studied intensively cannot be defended as representative of this polulation. A more detailed description of the sample and the setting is given in the next section. Suffice it to say here that it was expected that some features of any paradigm shared by such teachers would derive from commonalities in curriculum, in expectations for student performance in

science, and in the day to day circumstances of the classrooms being observed.

**Setting of the Study**

The work reported here formed part of a long term program of research on science teaching in Canada being conducted under the umbrella of the Canadian version of the Second International Science Study (SISS) being conducted by the International Association for the Evaluation of Educational Achievement (IEA). Details of the overall Canadian study have been reported elsewhere (Connelly, Crocker, and Kass, 1985; in press). A preliminary report of the international achievement study is also available (IEA, 1988).

Like other IEA studies, the primary focus of IEA/SISS was on cross-national comparisons of science achievement. The Canadian research team, hovever, used the setting of the IEA study to conduct a much broader review of science education in Canada and to engage in a number of basic studies of teacher perceptions and classroom practices. The underlying rationale for the broader approach was that achievement can only be understood in the context of curriculum and teaching practices. In particular, it was argued that thye way in which the teacher translates the intended curriculum into classroom practices is crucial to understanding the ultimate outcomes of teaching.

An early large scale teacher survey (Crocker and Banfield, 1986) identified a number of major sources of influence on teachers. These included the type of students in a class, school spirit and morale, learning style, and more immediate factors such as class size and approach to discipline. On the other hand, the underlying nature of the science curriculum was found to be of little influence on teacher decisions. One of the main purposes of the study reported here was to explore in more detail the sources of influence on teachers and, in particular to investigate how teachers integrate information on curriculum, students, school setting and so on into a set of classroom practices.

**Methods and Data Sources**

Data for this study were gathered using a combination of document analysis, interviews, and classroom observations. Policy documents, curriculum guidelines, and textbooks, were used to establish the policy context under which teachers function. The observational data base consists of some 250 hours direct observation in 23 junior and senior high school science classes. Teachers were also interviewed at the beginning of the study and on several occasions throughout the observation period. The primary focus of the interviews was on what has been called **curriculum translation**, or the process by which teachers interpret policy and curriculum guidelines and adapt these in formulating classroom activities. This focal area was chosen to create an appropriate link to the overall IEA/SISS study, which distinguished between **intended** and **translated** stages in curriculum, but which made no attempt to examine how teachers move vrom one stage to the other. Initial interviews were designed mainly to obtain teacher interpretations of the intended curriculum as described in the appropriate documents. Subsequent interviews were based on the observations, and afforded teachers an opportunity to elaborate on their reasons for engaging in particular activities.

Observation data took the form of field notes written during the course of the observation sessions. These field notes were edited to yield transcripts in narrative form. Interviews were of a semi-structured nature, based on a general set of questions, along with items allowing teachers to give their interpretations of some of the observed events.

Analysis of the data was based on an iterative process similar to that suggested by Glaser and Strauss (1967) for the formation of grounded theory. Recurring themes in the narratives and the interview protocols were identified and their interrelationships examined within and between teachers. Themes which showed stability were finally used as the basis for a more intensive paradigmatic analysis. Three of these themes are addressed in the following papers.

## II BASIC TEACHING REPERTOIRES

One has only to examine certain well known books on teaching method, such as that by Joyce and Weil (1986), or the content of methods courses in teacher education programs, to recognize that there exists a wide variety of basic approaches to teaching, and an even larger variety of specific techniques which might be applied. One might expect science teaching, in particular, to be characterized by techniques which attempt to draw directly on the natural phenomena being described and explained by science. Such techniques have long been advocated in teacher education, and are, in one way or another, built into many science curriculum programs, including those in use by the teachers in this study.

Despite this richness, one of the most striking things about the classrooms observed was the degree of similarity found in the basic approaches to teaching, and the relative narrowness of the range of teaching practices observed. This narrowness of repertoire has been noted in other studies, notably the recent work of Gallagher (1986) in science classrooms. In this chapter, we attempt to describe the kinds of techniques used by teachers in our study and, more important, attempt to develop some understanding of why particular techniques are chosen and others not. Here we attempt to look beyond the surface features of the situation, and refrain particularly from the argument that teachers are to be criticized for not using a wider variety of techniques. Consistent with our basic starting position, we argue instead that there must be something functional in the techniques used, or perhaps dysfunctional in those not used, and that teacher choices are grounded in particular paradigmatic ways of thinking appropriate for the setting at hand. In terms of what is advocated in teacher education, we ask the essential question of whether teacher educators themselves would act in the classroom in a manner consistent with what they advocate or whether the fundamental characteristics of the classroom setting lead almost inexorably towards the choice of some techniques and the rejection of others.

**Teacher Presentation: The Basic Classroom Process**

The image of teacher front and centre, chalk and talk, has frequently been used almost derisively to describe the most common of all classroom activities. Indeed, teacher presentation, using little more than oral discourse and chalkboard writing, was found to be by far the most prevalent form of activity observed in this study. Rather than deriding the practice, however, our interest is in describing teacher presentation in somewhat more detail than is usually done, and, more important, in exploring the question of why such a practice is so prevalent. The basic point is that such activity must be seen as functional or it would have long since been abandoned, particularly given the low esteem this kind of practice has been accorded by critics of schooling and by teacher educators.

**The Structure of Classroom Presentation**

The following excerpt from the field notes illustrate several aspects of classroom presentation:

Grade 9

> Dave (the teacher) introduces the notion of having models of atoms and points out that it is difficult to draw something that you can't see. He tells students that he will explain it all slowly and that they can then work on drawing some atoms and that the whole purpose is to find out how to take one element and join it to another to form a compound. He adds that they should be able to see why some elements can join and others can't by referring back to these models.
>
> Dave then draws a large F on the board and asks students what is the symbol for. The student questioned can't answer but another replies fluorine. Dave adds 19 and 9 to the diagram and labels 19 as atomic mass and 9 as atomic number. He tells the class to pay close attention since once they get going it will be easy.
>
> 19
> F
> 9
>
> Dave asks, rhetorically, what atomic mass means and then writes on board

Atomic mass = # protons + # neutrons

He draws this diagram explaining and asking several questions as he builds the diagram. He uses Switzerland as an example of neutrality and the sun and planets to explain the concept of an orbit, pointing out that "shell" is used as a synonym for orbit.

Dave then reemphasizes the charges on the three particles and uses the acronym PEN

P + charge
E - charge
N no charge

The sun and planet analogy is used again. He tells class to think of this on a minute scale. A student asks if they should copy this down. Dave suggests it would be best to focus on the blackboard. He then proceeds to recap on the three particles again, writing

Nucleus 2 particles (a) positive protons
(b) neutral neutrons

Shell negative electrons

Referring back to the sun and planets analogy, Dave points out that just like the planets we have a definite number of paths, which he illustrates with

putting earth, venus
and mars on orbits

He tells students that in the atom the first shell from the nucleus is the K shell, the next the L shell. This is written on board

K shell
L shell

Dave now asks for suggestions for the next shell. Students respond M and then N shells. Dave points out that they won't get out to the S and T shells since there aren't enough elements to fill out these shells.

Dave writes a list of the maximum number of electrons that can fill each shell, at the side of the board

K = 2

L = 8
M = 18
N = 36
O = 36
P = 36

He then refers back to the initial diagram of Fluorine

19 Atomic Mass
F
9 Atomic Number

At this point the class is interrupted by another teacher who comes to discuss the science fair. Dave tells the class to read pp 136-137 and examine chart on p 137. Some students read the assignment while others just muck around.

(D.M. 1 1-2)

This episode possesses the obvious common feature of the presentation; that of a single presenter addressing an audience. Beyond this surface feature, however, there are a number of important points of departure from the idealized types of presentations discussed above. We discuss here chalkboard use, the nature of audience participation, the extemporaneous nature of the presentation, calls for attention, and several other features to illustrate the points of comparison and contrast between this setting and most ordinary presentations.

It seems almost trivial to say that the most obvious departure is in the degree of use of the chalkboard. Some might argue that the use of the chalkboard instead of the more sophisticated visual devices which abound, is a mark of a poor presenter, particularly one who has failed to take the time needed to prepare visual aids. In discussing this matter with teachers, however, a rather different picture emerges. What we expected was that teachers would use the argument that there is insufficient time to prepare visual aids for the large number of classes which must be prepared each day.. What emerged, instead, was a sophisticated argument that the chalkboard has the distinct advantage of allowing a concept to be illustrated as it is presented, allowing rapid changes to be made, and allowing points to be recorded as they arise. In drawing a chalkboard diagram, for example, what is seen as important is not the quality of the finished diagram, but

rather the process of building the diagram. Even the common device of overhead projection transparencies with overlays cannot accommodate this requirement. To the teacher, the chalkboard is thus more like a sketch pad than a visual device in the normal sense. Its purpose is to permit the development of ideas, not to illustrate these ideas. Although the overhead projector can, in principle, be used in a similar way, the relative permanence of marks made on transparencies, and the messiness created when one's careful pre-prepared transparencies are marked up makes this device more useful for presenting finished products than for emerging ideas.

This brings us to another important point illustrated by the above episode. Essentially, the teacher is acting as if the ideas being presented are newly emerging from the class. While the teacher does do most of the talking, and is the source of most of the ideas, whenever the opportunity arises the class is called upon to contribute something, even if only a routine response, such as naming the element fluorine or continuing the letter sequence for the electron shells. It is significant that in no other form of presentation is such a form of audience participation elicited. Indeed, such devices as having audience members fill in a response to a relatively routine point would be viewed as ludicrous in most presentation settings. More generally, the idea of the presenter questioning the audience is something unique to classroom-like settings. In presentation settings, it is members of the audience who usually do the questioning, presumably since they are the ones attempting to learn something from the presentation. There is something incongruous to the fact that in classrooms it is the individual possessing the knowledge, rather than those attempting to acquire it, who does the questioning.

One of the most striking features of the classroom sessions observed was the almost total absence of anything resembling a script for the lesson. In fact, in discussing lesson plans, most teachers indicated that such plans existed "in their heads" rather than on paper. While the ability to speak extemporaneously is generally admired, its use tends to be associated with stand-up comedians, after dinner speakers, preachers, actors,and others with a non-academic message to convey. In many such cases, as in acting, a script has essentially been memorized to the point that delivery of "lines" appears spontaneous. Those with a fairly formalized agenda are likely to rely

on notes of some sort, if not on full scripts. One has only to note the number of hours spent by a teacher in a classroom over a week to recognize that what we witness in classrooms is not the well rehearsed lines of the actor, but something which suggests a remarkable feat on the part of teachers; that of being able to carry many lengthy presentations without either script or rehearsal. Few public speakers would take the risks associated with such an approach to presentation.

Why do teachers proceed in this manner? While there is no clear answer to this question, what is clear is that classrooms are sufficiently different from most other presentation settings to account for certain practices.

First, teachers can be expected to be highly familiar with the subject matter being taught, at least at the level of the textbook or other curriculum documents being used. As the above episode illustrates, the textbook is never far out of reach in a class session. Even if the presentation is not directly textbook based, both teacher and students tend to be aware of where they are located in the textbook {more needs to be said about the use of textbooks}. Furthermore, since lessons tend to follow a sequence grounded in the text, the teacher is much more aware than most presenters of exactly what the audience knows and, in particular, what has recently been done.

Second, relatively little new ground is covered in the typical class session. When one examines the concepts covered in the above episode, it can be seen that only one new idea, that of electron shells, is introduced. Most of the remainder of the discussion concerns concepts with which it is assumed that students are already familiar, though it is obviously necessary to continuously reiterate such concepts. The latter point is a key one in accounting for the ability of teachers to sustain lengthy periods of presentation. Much of the material is, in fact, not new, and only needs to be reiterated (either on student demand or on teacher judgment of need).

Finally, individual lessons typically form part of an ongoing sequence, in which the teacher knows what has been covered before and what remains to be done. Attaining closure within a lesson is thus not critical. One simply moves along in the content until time runs out, and picks up at that point in the next session. Teachers, in fact, indicated in interviews that

keeping track of where they left off is perhaps the major element of planning needed on a daily basis, and is often the only thing on which a note needs to be made.

In summary, then, presentations in teaching are unlike those in other settings in a number of important ways. Preparing, say, a forty minute class session for tomorrow morning is only marginally comparable to preparing a similar length presentation for a meeting of peers or clients. Likewise, the act of presentation itself is conducted using devices such as the chalkboard, questioning, covering small amounts of material, and so on, which lead to relatively large amounts of time being occupied without the teacher requiring access to much substantive subject matter. The professional knowledge involved in classroom presentation is not the same as that involved in other forms of presentation. A set of unique skills can be identified with the management aspects of classroom presentation, the development of ideas in an unsophisticated audience, the coverage of sequential content for which teacher and students have an external guide (typically the textbook), and the evaluative role of the teacher as presenter, as manifested in teacher questioning.

**Structuring**

The sense in which the term is used here is similar to that of Bellack and his associates (1966), who introduced the term as one of four major "moves" under their concept of the classroom as a "language game." In this sense, structuring refers to activities on the part of the teacher designed to organize the flow of events in the classroom, indicate what students are supposed to be doing at a particular time, or control movement, materials, or specific tasks. The following extract from the field notes will serve as a basis for discussion.

> Grade 9
> (P.H. 1-1-2)
> Pat is directing the activity. She is setting the progress rate by instructing students to carry out the same method at the same point in time.

Pat holds a chronometer. She instructs appointed students to hold their breath. They do so, starting at her signal. The partners of these students watch for the moment they are forced to start breathing again. This time is estimated from Pat's announcement of elapsed time at 2 second intervals. The timers in each group record the elapsed time for their subject. (all of this follows mild exercise - walking, which the observer had missed).

During a pause, the students begin to chatter. Pat asks for their attention and inquires if all are ready to proceed with the next part of the activity.

P. The third part is a running part. I want you to jog on the spot . . . pretend that you're jogging down the road. Don't go crazy with it. Remember you have to do this for 5 minutes. Remind you . . . procedure is the same as for the walking part. Use the time wisely. After finishing this part I can allow only a few seconds to record breath-holding, or else we will run out of time.

Students have obviously been pre-selected for this part. There is no fuss as students prepare, one from each group. Pat tells students to spread out as she does not want them bumping into each other. Pat then signals to start, timing them with her chronometer. She warns other students to remain seated.

. . .

Pat now instructs the students just participating to stand and those sitting to stand. She tells the students that before they proceed they must wait for the two female students to return from the washroom (one had felt faint from the exercise and was sent, with a companion, to the washroom).

Pat sits at the edge of her desk. She engages a student sitting at the desk closest to her in a brief conversation. She then sends this student out to the washroom to check on the two others, telling her to report back as soon as possible.

Pat asks students if someone who has completed the running can loan another a pair of sneakers. Safety is a factor.

Pat leaves the room momentarily to check on the student ill in the washroom. She returns, spaces out the students who will be running, and cautions all present about engaging in nonsensical behaviour as they proceed.

On her signal, students start running. She sets their pace at a safe rate. As they start to move, she makes sure their pathway is clear, cautioning one seated student to "get your knees out of the way."

Pat announces "3 minutes to go." She cautions students to slow down. Again, she sets the pace. She spots and cautions a student who has been trying to strike another as he runs by. Another student is told to stop running as he appears to have a cramp from the activity.

Pat stops the running. As before, participants return to partners who time respiration rates under her timing signals.

It is worth noting, by way of contrast, that this episode is much more complicated than those used in discussing teacher presentation. Also, it should be noted that such activities differ from the typical laboratory session in the amount of moment to moment teacher direction of the work. This kind of activity represents the extreme in what we are calling structuring. In effect, the teacher here acts somewhat as an orchestra conductor or a stage director during a rehearsal. All student moves are controlled by the teacher. Students are essentially expected to wait around for their cues. Any student activity not carried out under teacher direction is considered illegitimate, as illustrated by the warnings and cautions issued by the teacher as the activity progressed.

A further feature of this sort of activity is the emphasis on procedure. In fact, it might be argued that structuring activities are essentially procedural in nature. Unlike teacher presentations, there is little in the description of events to indicate that students are supposed to be learning anything, except perhaps to follow directions. Obviously if anything is to be learned from such an activity, there must be some transformation of procedural matters into substantive ones. This, of course takes us back to teacher presentation, or to some other form of work which can serve to integrate the data gathered by following the procedures described. Again this is where the continuity of classroom work must be considered. Unlike a stage performance, for example, this activity will not be repeated over and over until the procedures are perfected. Rather, the participants can be expected to move on to some other activity which places the work in a substantive context, much as a plot, for example, eventually emerges from the integration of episodes in a performance.

The episode illustrates a more general point about classrooms, namely that they are not self-sustaining work places. Rarely is any student

judgement exercised about what to do and when to do it. It is the teacher's function to set the task, give the directions, set the pace, keep the activity moving. It is difficult to imagine in many of the classrooms observed in this study, that students would have done anything, except perhaps chat among themselves, had the teacher not appeared on time or been absent for a session. The situation with substitute teachers, referred to be several teachers, illustrates this point. The presence of a substitute teacher creates loss of continuity, in the sense discussed earlier, where the teacher is aware of what has gone on before, and simply picks up as if there had been no interruption in time. A substitute teacher, not possessing this knowledge, finds it essentially impossible to conduct an ordinary presentation or to orchestrate the setting in a way which makes the work move along in the normal manner. This is reflected in teacher complaints about the loss of time when it is necessary to be absent for a day. Interestingly, it is generally understood that students cannot simply be allowed to carry on independently with their work when a teacher is absent. The requirement that a teacher appear and orchestrate the setting in some fashion illustrates the pervasiveness of the idea of structuring.

**Supervised Practice**

The term supervised practice is used here instead of the more common term seatwork, to convey the idea that what goes on during much seatwork activity is, in fact, drill and practice exercises carried out under the supervision of the teacher. The most common vehicle for such work is the ubiquitous worksheet of problems or questions prepared by the teacher. Also common is assigned problems or questions from the text or a workbook. During such activity, the teacher is most often found circulating about the room checking on the work of individual students, responding to individual queries and, at the same time, monitoring the class as a whole. The following excerpt illustrates a typical session:

Grade 12 (Chemistry)

The class now turns to work on the worksheets (these are on mole calculations and the use of scientific notation). Kevin circulates around. Several students call out "sir" and put up

hands. Kevin ignores most of this. A couple of students can be heard talking about a truck someone has bought, loudly enough to be heard by the whole class.

Most students work away at the problems, some alone, others talking among themselves. Some call out to others asking for answers and so on. Kevin speaks very sharply to one student from across the room, but retains his characteristic low voice. The rest of the class seems not to notice. Several students still have their hands up and are calling "sir". Generally, Kevin goes about his business seeming not to notice these (the observer makes a note to ask about whether he keeps track of students looking for his attention). Again Kevin reprimands a student for talking. This person happens to be one of the louder ones. Nevertheless, for the most part, the group to which this student belongs is on task. Kevin goes over to this group and one student explains at some length his calculations. Kevin asks "Where do you want to go? How do you want to get there. Find the number of particles" and so on.

A girl calls out across the room to a boy for an answer. Her answer seems to be way off, according to the answer given by the other student. She remarks "we're not all smart like you, Craig."

About half the students seem to be working alone. The rest are in rather loose groups which seem to be thinking out loud; asking for answers, giving answers, and so on. The prevailing question seems to be "what did you get for this one?" I notice one student explaining to another at some length to another that the reciprocal of $10^{-23}$ is $10^{23}$. Many students are obviously having difficulty. Most problems seem to centre around calculations, the use of scientific notation, conversion of units, and such matters. Some of the problems, however, have to do with basic concepts such as that of mole.

I observe one girl who goes to another who goes over her calculations in great detail, reworking the calculations, and reminding her to convert the units. She reminds the other that "where you used moles you should have used grams. You have also changed millilitres to litres." The first girl returns to her desk with this advice and begins to rework the problem.

Kevin looks over a student's shoulder. The student remarks somewhat defensively "that's not right, is it?" Kevin indicates that it is "right on."

Kevin finally picks up a student who has had his hand up for some time. Another calls out loudly "sir" but is ignored.

The student observed earlier being instructed by another now goes over and explains the whole thing to a third student. This

student now takes on the teacher role, questioning, probing, giving directions, and so on much as the teacher does when explaining a problem to a group.

There is now a chorus of "sirs" from the students. Kevin finally comments "take your time boys" but he nevertheless goes over to the students calling out. It is difficult to follow the conversation here. Kevin is talking to an individual student "This is the mass. You find the number of moles first. Then you find the number of particles in a mole. What are you given? That is the first question." He points to the example on the board, and follows this through.

Students are calling out across the room, comparing answers. One calls out to Kevin "what do you do if you have four significant digits but only need two and you can't shorten it?" Kevin replies something about rounding off.

At this point the bell rings. Students immediately get up and leave, with Kevin calling out as they go out the door "finish up that sheet for Monday.

Returning to the regular classroom, I ask Kevin if he keeps track of students with their hands up. He indicates that he does, but that they have to wait their turn. He is quite aware of the group work and believes that most students are on task.

The surface features of this kind of session are familiar enough, and fit the description given in the introductory paragraph. Closer examination, however, reveals a situation of enormous complexity. At the same time, a particular modus operandi on the part of the teacher can be discerned, which shows how a teacher can build into a repertoire the means of coping with such complexity.

First, it is important to note that sessions of this sort were not found to be particularly frequent in high school science classes. (Laboratory activities, which bear some resemblance to the situation described here, are treated separately in the next session). In some cases, work of this sort was assigned as homework, which was then corrected in class. Homework correction turns out to be a rather different kind of classroom activity from that described here.

To the observer, one of the most obvious features of this type of session is the amount of off-task behaviour resulting from students waiting to get the teacher's attention. This is evidenced in the excerpt by the calls

of "sir" and the hands up, the latter frequently occurring for long periods of time. This is obviously related to the difficulty of the task. The more difficult the task the more of this sort of behaviour one would expect to occur. Sometimes, problems can be resolved through collaboration among students, a point illustrated several times in the example. Often, however, considerable time elapses before a student can be brought back on task through some form of intervention. In this case, the teacher was aware of the backlog of demands, having resolved the problem in his own mind by the view that they have to wait their turn. The situation thus seemed not as problematic for the teacher as for the observer.

This situation can be analyzed in terms of its contrast with the core activity of teacher presentation. First, it is obvious that the focal point of the teacher has shifted from the class as a whole to individual students. The focus for the students, in turn, shifts from attending to the teacher to a variety of individual and collaborative activities, some of which are task-related and others not.

Once freed from the constraints imposed by the presentation format, the teacher is in a position to engage in a variety of activities. It is significant, however, that teachers rarely make use of seatwork sessions to catch up on paperwork, leave the room, sit and monitor behaviour, or other activities not directly related to the task at hand. Rather, the teacher is almost always found circulating about the room, attending to individuals or small groups. A variety of detailed actions can be observed as part of the general pattern. For example, teachers spend widely different amounts of time with students, ranging from the glance over the shoulder to a mini-lecture of a couple of minutes or more. The most common stance of the teacher in interacting with students is a probing one, in which student questions are not answered directly, but leading questions are asked to get the student thinking in the right direction. Kevin's admonition "What are you given? That's the first question" and his pointing to the example on the board are illustrative of teacher attempts to have the student work through the problem.

In this type of setting, there is an obvious trade-off of teacher time and attention between monitoring the class as a whole and dealing with individual student problems. Unlike in a presentation setting, the teacher's

time here is clearly divided up among the students. The more time spent with one student, the less is available for others and for monitoring the class as a whole. The backlog of demands for teacher attention is one major consequence of this division. Although this is not well illustrated by the above example, frequently one finds the teacher alternating between individual and class attention. The teacher uses a problem raised by one student, for example, to instruct the whole class on the same point. This leads to a series of calls for attention and interruptions of the activity.

This leads to the important idea that, in terms of teacher time and attention, supervised practice is a zero sum game, in which one student's gain is another's loss. The essential area of teacher judgment required is that of determining how to meet the various demands. Kevin's solution to this is expressed simply by the dictum "they have to wait their turn." Other teachers have suggested different rules of thumb, such as meeting the most persistent demands, having a general notion of who most needs assistance, or having a systematic pattern of movement about the room.

In any case, an observer is left with the impression that it is essentially impossible for a teacher to meet all demands in the supervised practice setting, especially when the subject matter is difficult, and that many students are left dangling, without the help needed to keep their attention on task. In a fundamental sense, therefore, one might hypothesize that such sessions are inherently less productive than presentation sessions. This hypotheses seems to be borne out by quantitative studies of teaching, in which whole class direct instruction is generally found superior to other activities. The major exception to this seems to be the **cooperative learning** situation (Slavin, ) in which student work is organized in a collaborative fashion quite different from what is witnessed in the setting described here.

This leads to a final point. Some evidence of student collaboration can be found in the above episode. However, this collaboration is essentially impromptu in nature, consisting either of students who happen to be seated in close proximity or, more significantly, some students seeking out others whom they know are likely to be able of solving the problem at hand. The comment "we're not all smart like you, Craig," indicates an awareness on the part of students of who is most likely to have the solutions. Nevertheless, there is no evidence in sessions such as the one described, or in many of

the teacher interview comments, that teachers are active in creating settings in which brighter students instruct others or in which there is provision for formal collaboration in the sense described in Slavin's work, for example.

**Summary**

The above examples illustrate certain prevalent aspects of teacher repertoires. Other important aspects, including laboratory work, correction and feedback, notetaking, and the like overlap these to a considerable extent. For example, it might be argued that laboratory activities represent to the teacher an exercise in structuring as much as one of learning about science processes. Similarly, notegiving and notetaking may be seen as an integral part of presentation.

Looked at more broadly, this view of classrooms leads to the hypothesis that may teachers see their work in terms of planning for and carrying out certain functions which are only indirectly related to the surface functions of the classroom as a place for learning or the curriculum as the embodiment of a body of knowledge. Rather, it might be argued that a class of students can be seen as a setting to be structured, as an audience for a presenter, or as a group of workers to be supervised. In fact, as researchers such as Doyle (1987) have pointed out, it is useful to analyze the classroom as a work setting, possessing features in common with offices, factories, or other such settings. What is interesting about such settings is that workers need not have a sense of the goals of the enterprise in order to carry out their assigned tasks. Presentation, structuring, and the like can become ends in themselves. Planning can be thought of in terms of devising the best means of performing tasks. Goals, as more remote entities, may still be served, but only incidentally as a result of the completion of many more immediate tasks.

Before the implications of these points are examined further, it is necessary to look at the classroom from some slightly different points of view. The first, which we have termed **orchestration of the setting**, is essentially an extension of what has been discussed in this paper. The second has to do with another aspect of a work setting, that of the nature

and control of rewards. These topics form the basis for the next two papers.

## III ORCHESTRATION OF THE SETTING

The term **orchestration** is used here to refer to the manner in which the teacher organizes the full class setting and ensures that the group progresses through the tasks at hand. The term is meant to be rather broader than the earlier notion of structuring. In particular, the idea of orchestration is meant to capture global features of a lesson, typical patterns of instruction, and the rules and and routines which prevail.

The design of the study provided opportunity for teachers to describe the orchestration of lessons in their classrooms and also for researchers to observe the teachers during a sample of lessons, and then to ask them about these lessons later. Most teachers in this study were observed to conduct their classes in the general manner they had described, but the time taken to carry out the phases of lessons described varied considerably from the original reports of "a typical lesson."

In this paper, a description of orchestration of events in typical lessons is first presented in two sections, reported events and observed events. Following this is a description of the instructional emphasis observed in different classes, the routines developed to structure the classroom events in terms of materials and management of students. Finally, a more detailed examination of teacher student interactions is presented. The events described here are drawn from the subgroup of eight junior high school classrooms as the structure of the curriculum and the nature of the classroom activities at this level provided more graphic illustration of the notion of orchestrati than did the senior high school classrooms.

### Typical Lesson

**Teacher Reports.** Most of the teachers described a typical lesson in

terms of the activities forming the basis of the prescribed curriculum. This is available to students in a lab-text.

The most common image described by teachers suggested that teachers provide a brief introduction followed by the students spending most of the class doing a guided inquiry type of activity, described in detail in their lab texts. Then the teacher would have a brief discussion about the activity and the students would write it up and answer the questions provided in the book.

> **Brian:** I like to pick up from where I left off last day. If we have an activity, I like to say a minimum, so they find out for themselves, give a few cautions, a time-frame, then depending on the level, supervise or dig in with them. Finish before the end of the period, have a few words, set some homework, let them know what we are going to do next day.

Further description of events was provided in terms of the number of activities done per timetable cycle of 6 days. Most teachers indicated 1 or 2 activities per cycle. The teachers varied in their emphasis on the amount of instruction provided before students did activities, but most described clear instructions and expectations for these students.

> **Researcher:** Is there such a thing as a typical lesson?
>
> **Kathy:** Not really, but for the activities I introduce the activity and summarize at the end. The tangible products of the classes would be activity write-ups and the answers to the questions accompanying the activities.

Only one teacher did not hold the activity dominated image for his classes and reported, "All my classes are different. I have discussions, demonstrations, lectures, film strips, lab activities."

**Observed Events.** Observations of lessons showed that most teachers did organize their classes as they had described, but the events described for a typical lesson frequently required more that the 40 or 50 minutes of available lesson time. Where students were not expected to do homework preparing for the activity or writing up results and answers to questions, more than half the time on any activity was spent with students receiving

instruction, discussing or writing about the activity. A sample of this type follows.

**Observation:**

In a class where students are to separate salt from iron filings the teacher starts by saying:

In the previous class you were in groups to develop procedures for 2 ways of separating salt and iron. Take a couple of minutes to discuss.

5 minutes of teacher and student talk follows in which the teacher has drawn attention to the steps in the book, elicited from students the properties of salt and iron and gone over the ways to separate the 2 substances.

Then the students spend about 25 minutes doing the activity while the teacher encourages and prompts them. A 5 minute clean-up leaves time for a 2 minute discussion. The teacher tells them they can do the writing assignment next period. The next class 20 minutes is spent completing written work about this activity.

Observations of the lessons showed that several teachers were very explicit about their expectations, the procedures to be followed and records of the activity which students were to make.

**Observation:**

The teacher explains what she expects the student to do by the end of the 2 activities they are engaged in. She explains she requires diagrams of a perfect and imperfect salt crystal and also answers to questions 1, 2 and 3. Students make a few queries ... The teacher emphasizes they should only draw what they see, and not what they think they see. Other questions follow about terms in the book, dissolving and crystallizing. The teacher explains and then repeats their write-ups are due the following day.

The teacher then takes half the class into the lab where the equipment is already set up. She goes over the procedure for the two activities, indicating the chemicals required at each stage, and reminds the students how to focus in the microscope. She tells them to start activity 3 first and then to go to activity 2 while activity 3 is proceeding.

The students proceed with little problem.

Other observations showed that students in many classes did spend appreciable time doing seatwork, making notes or answering questions.

> **Researcher:** I observed students were involved in some seatwork. Do you often set aside class time for such activities?
>
> **Martin:** Yes, I could say often ... to follow up on an activity or something that we've finished because that is a weak class.

Thus, the major picture of lessons which emerged was of all members of the class spending the same time in a sequence of 2 or 3 lessons focussing on one activity from the curriculum. When the teachers selected an activity they did use it much as it was described in the student text, but the actual learning experiences of the students differed considerably as a result of the different instructional emphases of the teachers.

**Instructional Emphasis**

All teachers were teaching the same program, and had access to a detailed teacher guide setting out the goals and objectives of the program giving an extensive rationale for the learning activities provided and suggesting instructional approaches and use of alternate activities. The concepts of the course are clearly stated and the process goals of the program are also made explicit.

**Conceptual Basis of the Curriculum.** The most frequent observation made in these classrooms was that teachers took a business-like approach to the program. Some drew the attention of the students to the behavioral objectives stated at the beginning of each unit. Others were direct, but brief.

> **Laura:** "I'm going to start the unit on genetics ... page 82. Up to now we've been talking about Mendel and Heredity, taking the historic view. The chapter is going to explain the modern sense."

Some teachers frequently referred to assignments or the activities by number from the lab book, rather than by conceptual content.

**Ken:** "How many have done the assignment? Who had no problems? Who had some trouble with it?"

**Dan:** "We will be doing Activity 1 on page 153." Then the teacher described the activity explaining the materials needed.

The topic of the activity was not mentioned, so this class did not hear the conceptual terms, "physical change" and "chemical change" at all in the introduction to the activity.

Other teachers did mention topics at the start of the lesson.

**Kathy:** "You remember we are investigating ways to connect up bulbs and cells to make a circuit."

**Brian:** "Now we have an activity to do on the topic we have talked about, impure substances."

These two introductory statements to the class illustrate the business-like approach to the start of lessons which is described and discussed further later in this paper.

Most teachers stressed they wanted the students to understand the activities and went to considerable lengths to explain the conceptual content.

**Dan:** "They need multiple exposure to the concept (mechanical advantage): the text, the lab activity and demonstration."

Many teachers used a significant part of class time explaining concepts by means of diagrams and problem-solving on the board. Often consciously repeating things over and over. "You've got to keep repeating stuff. I do this in every unit and every class." The one teacher whose main professional experience had been in high school explained concepts at length and in detail, but reported, "The simpler I can keep it the better."

Some teachers described their teaching in terms of doing anything to get the idea across and used dramatizations, analogies, models and other means described in detail in the paper on repertoire in science teaching.

In the typical, and critical, problem of introducing abstract concepts to teenage learners, the most frequent method used to explain concepts like molecular structure and mitosis was diagrams on the board.

**Researcher:** Do you use any methods to reduce the abstractness (of atomic structure)?

**Kathy:** Well, not really. I use the diagrams a lot. That helps.

Teachers varied in the degree to which they wanted students to understand and explain things in their own words. The routines that were observed for students taking notes and answering questions from the text appear to explicitly illustrate each teacher's particular beliefs about student capabilities with respect to communicating their own understanding of the ideas.

**Observation:** The teacher writes 5 terms on the board and urges students to write out the definitions and learn them. She reminds them to write definitions in their own words and not to copy them from the book.

Many classes did not appear to write many notes, simply answering the lab text questions. Other classes wrote their own notes as the teacher talked or after a period of explanation.

**Observation:** The teacher presented a relatively detailed account of covalent and ionic bonding. Students followed carefully and seemed to be taking quite detailed notes. Later the teacher reported she did not necessarily expect them to take notes, but wanted them to listen and understand.

The classes of two teachers copied notes from the board and one used prepared overhead transparencies quite extensively.

One teacher deliberately told students not to open their books, but just to listen while he explains the topic. Later he commented that "this class is a slower crowd and can't do two things at once, therefore I want them to concentrate on the teacher."

**Process Skills.** A major focus of this activity-based program is an understanding of the scientific method, and explicit use of the processes of science. Teachers observed in this project did not pay conspicuous attention to naming the processes students were using in class, except for one teacher who did stimulate predictions about the activities. Others reported a more

global intent to develop an understanding of science and emphasis on the processes without explicitly using their names.

> **Greg:** "You know I often say in activities, it didn't work, meaning that's the life of a scientist."

> **Dan:** "I rarely use the process terms with students except for the term hypothesis in some of the activities."

Although these teachers did not appear to explicitly address learning the processes of science many of the teachers focussed on the use of correct scientific procedures, such as doing accurate lab write-ups, like Pam who explained, "I like to encourage the correct procedure and style in report writing."

Most of these teachers reported marking a sample of lab write-ups and some required students to be able to write up a demonstration lab activity as part of the evaluation for the course.

Most of the teachers demonstrated specific lab techniques, with some being quite strict about proper psycho-motor procedures, while one teacher who had only two university science courses in preparation for teaching junior high science, paid little attention to lab skills.

> **Researcher:** I noticed some of the students held the filter paper with their fingers ...

> **Greg:** ... I didn't spend any time on that one. I guess I'd assumed that there was a diagram in the book on how to fold the paper and put it in the funnel and what not ...

> **Researcher:** I noticed also that they held the filter funnel with their hands. You don't set it up in a ring stand?

> **Greg:** No, where there are 4 or 5 in a group, one can hold it and the other can pour.

The only emphasis on specific science processes seemed to arise from the activities and the processes inherent in them. Thus, the focus on processes of science is implicit rather than explicit in these classes, although proper procedural reporting was explicit in all classes.

**Teaching Thinking Skills.** The teachers displayed considerable variation in the responsibility they placed on the students for their own thinking and learning. Although four of these eight teachers specifically mentioned that their emphasis was on getting the students to think and figure things out on their own.

> Greg: I'm not one that really sees the teaching of science for science's sake ... if we can get them thinking and some of the processes in place, I'd much rather that than some of the content ... Science is a vehicle.

Another teacher whose reported goal was to have students think, was observed giving the students notes, used a lot of repetition in teaching and admitted there is a lot of memorization involved. Other teachers were more consistent in demanding the students think and decide things for themselves.

> Pam: "They're doing a little research project now ... It's up to them what type of presentation or what type of audiovisual to use." In class this teacher was observed frequently saying to students, "It's up to you."

This goal of developing student thinking skills appeared to be one where intentions and observed practices were often incongruent. One teacher made explicit what many teachers appeared to grapple with when teaching these adolescents.

> Laura: I think what I try to do is to get them to attack science from the point of view of being able to think about things and being able to figure things out on their own. And this is difficult at this level because you know, thinking for themselves doesn't seem to be one of their strong points, so we try and get them to organize their materials and try and figure things out. For some it works out quite nicely because they're maturing and so on. For others they find it difficult. There's a lot of memorization of course involved, and the ones that don't think very well for themselves I guess get that anyway.

**Other Areas of Emphasis.** Teachers also described a number of other areas of emphasis in their instruction, including relating science to the real world, and addressing motivation and affective attitudes in science. Getting and holding attention, and generating enthusiasm were mentioned as problems, although it was rare to observe instances where these problems were addressed explicitly. An exception was the practice of some teachers of deliberately a variety of activities and alowing students to develop their own interests.

In summary, the instructional emphases of these teachers varied sufficiently that the learning opportunities provided to one class of students were clearly different from the opportunities in other classes, and frequently from the intended opportunities described by the curriculum planners. The most common difference from the intended curriculum arose from omission of optional activities planned to reinforce and extend basic concepts.

**Classroom Routines**

Teachers were found to use routines in a variety of aspects of their classroom work. Among the areas in which routines were used were the organization and management of materials, organization of students, instructional management, and behaviour management. In the interest of brevity,we confine the discussion here to the issue of how teachers employ routines for organization of students.

All teachers in this study had access to laboratory facilities for most of their science lessons. Most teachers had students working in groups of 3-6, depending on class size and availability of lab space and materials. One teacher with a very large class split the students into two groups, taking half the class into the lab and leaving half in a classroom to get on with other work.

The most common situation appeared to be that all teachers structured all students to do the same activities at the same time. Only one teacher was observed allowing students to do independent activities or projects, after finishing the prescribed core activity in class. This teacher had a small class of 15 students.

> **Martin:** "You have questions to work on ... The rest of you can continue to work on your science projects." The teacher remains available for

students. He answers a question concerning design of a backboard, helps students with the questions ... discusses a chart displaying the project ... supervises one group who are not lighting a Bunsen burner properly ... aids students examining diagrams ... disassembles some apparatus, helps a student with the textbook ... check son the progress of 2 students ... cautions 2 others to behave properly ... sits at a back bench observing ... discusses a water molecule with one group ... advises students on poster size ... aids with a model ...

This segment of classroom observation illustrates the diversity of activities which may arise and the mental flexibility required of a teacher in a class setting in which activities are not orchestrated in some specific way. Most of the teachers felt it was simply impractical to allow students of junior high school age to do individual or unguided activities.

All classes observed were reported to be heterogeneous in ability. Teachers reported different specific plans for grouping the students during activities.

One teacher preferred grouping students of similar ability, based on his own previous practical knowledge.

**Brian:** I found the year before last ... that I had 3 boys who ended up in a group by themselves who were desperate characters, and after the first week or so their work came up to par with the rest, because there was no one there to do the work for them ... and that way I had less problem with others complaining about them.

Another teacher in the same school thought that mixing students in heterogeneous ability groups probably stimulated some peer teaching, but this same teacher reported elsewhere that students liked a lot of repetition and help with their work.

**Researcher:** They don't ask a lot of questions, do they?

**Greg:** No they don't.

**Researcher:** I guess it's all pretty clear to them.

**Greg:** Yes, and I will say mainly because there are some better students in each group. I think

> they usually sort of take the lead and the others follow and they probably ask those individuals.

Other teachers allowed students to form their own groups, unless problems arose and reported that students did help one another.

> **Pam:** They are in a group so they can talk about it (the activity). I'm always telling them, make sure everybody has something to do ... If someone is doing something, watch them, make sure they are doing it right as far as you are concerned. If you think they are doing ti wrong, tell them, discuss it, talk about it. If you can't agree, call me.

Thus, all teachers observed followed the prescribed activities with students working in small groups as required by the laboratory facilities available. A pattern is emerging of some teachers who make more effort to plan the learning opportunity for the optimum student performance and others who simply plan for the activity to be done.

The organization of these classes for activities revealed some broad commonalities, determined apparently by the curriculum itself and the typically large class in a lab facility with a restricted number of working areas. The specific routines observed and explained by the teachers revealed firstly that some teachers are more assertive in structuring activities based on their personal beliefs and previous knowledge, while other teachers are more passive in outlook and present the activities in a way they perceive to be required and which is congruent with their personal teaching style.

**Discussion**

It is possible to summarize the main aspects of teacher orchestration of the settting in the following terms:

1. Teachers generally plan for all students to have the same experiences at the same time. Lessons focussed on a prescribed class activity, its initiation, implementation, and completion.

2. The activity nature of the curriculum was apparent in almost all classes. However, the objective of having students proceed through the program wiht a minimum of help from the teacher was not visible in practice. Teachers generally expressed the belief that a high degree of structuring is necessary in the conduct of classroom activities.

3. The perceived need to get on with activities sometimes appeared to override the conceptual emphasis in the curriculum. The selection

and presentation of activities was often routinized, though the reasons for the routines were not always evident.

4. The problem of presenting concepts to a wide variety of elarners was addressed for the most part by repetition using presentation and chalkboard diagrams

5. Teachers typicallly taught psycho-motor skills explicitly and process skills implicitly, anthough the latter were an explicit area of emphasis in the program being used.

6. Discussions occurred occasionally, but rarely interrupted the palnned flow of the lesson for most teahers.

The findings of this study do not fully agree with observations reported by Gallagher (1987) that teachers are poor presenters of information, frequently digressing from the topic and teaching without a lesson plan. While some observers might be critical of the amount of academic learning time in which students are fully engaged in learning in some of these classes, the teachers clearly knew what they had planned for each class. Although teacher images of lessons appeared to be of a flow of segments interrupted inconsequentially by other classes, this planned flow of introduction, implementation and conclusion to activities was a salient feature of the orchestration of these classes.

Exploration of teacher and student interactions and the routines teachers used for structuring their classes showed that the predominant feature displayed by these teachers was the notion of getting down to the business of doing the science course. The specific routines for organization of materials, grouping of students and managing the environment in general reinforced the notion that most teachers do plan for classes to proceed in a reasonably efficient, controlled and safe manner with a recognizable product at the end in the form of student cognitive knowledge. Only a few exceptions to this pattern were observed as some teachers worked towards more diverse goals for their students.

Perhaps the key word in the discussion here is 'worked.' Not all teachers in this sample made the same efforts to structure the learning environment to meet the observed needs of each class, and some clearly acted on the basis of habit or feeling that particular routines worked. Duffy (1977) suggested that teaching in practice is not always consistent with teachers' expressed beliefs, and this study did record some incongruencies

between teacher belief and practice. Duffy suggested some teachers are more strongly influenced by their environment, and this idea is supported in the notion of a functional paradigm which represents widely demonstrated behaviours.

One point worthy of discussion for this group of teachers is that most have taught for more than the 5 years since this program was introduced. The norms of teaching behaviour previously were teacher-centred classes, recitation the dominant mode and knowledge the main student product. The new program had some different goals, needed new teacher and student behaviours and a new set of student products which are not so easily measurable.

Thus, the suggested behaviour shift required has been incomplete for many teachers, for a variety of reasons. A predominant influence is apparently the students, who some teachers explicitly felt could not cope with independent learning. In many classes, students are still exposed to recitation teaching where they take a passive role in the teaching-learning situation. This role is inappropriate in this type of science program, but acceptable in other classes, so students may be reluctant to change unless forced to by a teacher who actively asserts his or her own beliefs about science education, the curriculum and student learning. Dodd (1985) described how teachers differ in their investment and interest in learning to teach in new ways, and these teachers showed similar variations in effort to adopt behaviours to meet new curriculum goals.

Watts and Bentley (1986) have suggested that many teachers use methods of teaching inappropriate to the underlying assumptions of the curriculum. There is some evidence of this among teachers in this study, but the reasons appear to be diverse, where they are explicit. This small sample of teachers also illustrates quite well the idea that teachers' perceptions of the program and goals of the curriculum are crucial as to whether these are literally translated into practice, or transformed during during translation into practice which resembles the intended curriculum in some features, but not in all.

## IV THE PERVASIVENESS OF EVALUATION

"Grades are the currency of the school." This is how one of the members of our research team expressed an incipient idea based on an initial reading of the observation field notes. Even this cursory examination revealed the high frequency of references to evaluation, the extent of testing, the concern with grades, and the systematic recording of grades for just about everything done in the classroom. This chapter examines the place of evaluation and grading in the classroom setting, and its relationship to other aspects of classroom life.

Tests, quizzes, assignments, formal examinations, and the like constitute the formalized paraphernalia of evaluation. Our main concern here, however, is not with the instruments, but rather with the perceptions of teachers and students on evaluation, how these manifest themselves in classroom action, and with the way in which the evaluation system influences daily life in classrooms. What we are attempting to portray is a picture of evaluation not only as something which occupies a certain amount of classroom time, but as a driving force behind classroom activities, and a primary basis from which both teachers and students derive interpretations which determine the course of classroom life.

### The Evaluation System

A preliminary word is required on the structure of the evaluation system in the school setting in which the study was conducted. In this setting, schooling culminates with students writing a common set of "public examinations" prepared and administered by the Provincial Department of Education. Such examinations exist in all subjects at what is known as "Level 3" in the system, the equivalent of Grade 12. Most such examinations are written in the final year of a student's school life, though some may be written earlier if a student has taken a level 3 course in an earlier year.

The external examination constitutes 50 percent of a student's final grade in a course, with the remaining 50 percent being contributed by school based evaluations. Passing grades are required on a specific number of such courses, forming a particular pattern. At the end, a provincial certificate is awarded attesting to the student's satisfactory completion of the required pattern of courses. Such a certificate is the ultimate credential used for admission to advanced education or for entry to various occupations. It is important to recognize that not all jurisdictions in Canada, or elsewhere, maintain such a formal external school leaving examination system. Nevertheless, end of year examinations are common at the school or school district level in most areas. The main difference in the system described is that the teachers in a particular school have no control over the content of the examinations, and that school leaving certificates other than those based on the external examinations are virtually worthless in the marketplace.

**Influence of the Public Examinations**

A perusal of teacher test papers and other materials gathered during the observation sessions revealed that one of the most obvious influences of the public examinations is the tendency to emulate the form of these examinations in school tests. Rather than "dividing up the territory" such that teacher evaluations measure some aspects of a course and the public examinations other aspects, there is a large degree of overlap between the two forms of assessment. The public examinations cannot measure such things as participation, and do not attempt to measure laboratory skills, for example. These things are not therefore accorded high proportions of grades in teacher evaluations. Rather the largest proportion of teacher grades go to tests which resemble closely the public examinations.

The more interesting aspect of public examinations concerns the prevalence of references to these examinations in ordinary classroom discourse at the high school level. Such references take several different forms. One of the most common is what we might call the analogy or parallel case. A test item will be presented which the teacher will identify as resembling closely the sort of item which might be expected on the public examinations. A second type is the identification of content which students

might be expected to have to reproduce on the examination. A variation of this is identifying material not likely to appear. Much discourse surrounding these points begins with student questions on what they might be expected to be responsible for.

It is clear that these references reflect a concern with identifying what should be learned thoroughly and what deserves less emphasis. More broadly, this may be interpreted as an attempt to reduce large masses of subject matter to a core which is manageable and for which there is maximum payoff for effort invested. The latter interpretation is made more plausible by the frequent complaints uttered by students when large amounts of work are required for minimum marks. (This relates to a somewhat broader point to be examined later).

Concern with public examinations intensifies near the end of the school year. What is interesting here is that teachers attended to this concern in quite different ways. Intensive observations near year end indicated that some teachers spent almost no time summarizing the course, for example, while others proceeded with systematic summaries lasting several days. The latter were most often concerned directly with identifying material likely to appear on the examinations. In addition, some teachers spent time on the specifics of test taking, the exam format, how to make best use of time, and the like. Others would address specific areas known from the teacher's past experience to be problematic.

Despite this heightened concern, there was little evidence of direct coaching for the exams. Although past exams are available in published form, such exams were rarely in evidence in classrooms. In fact, the pacing of courses was such that few teachers had time towards the end for more than the brief summaries discussed above. None, in fact, spent more than a few days on such summaries. At the same time, though there was some concern at not having adequate time to cover course content, this was not an overwhelming issue for most teachers. Experienced teachers seem too have developed a sense of pacing which would just allow the course to be covered. As a general rule, this pace was one which did not deliberately allow for a substantial review period.

Teacher reactions to the examinations varied somewhat, but showed no extremes of like or dislike. In particular, there was little questioning of the

fundamental principle of such a system. Most concerns centered around details of the exams themselves. One teacher, for example, showed the observer a detailed critique of the previous year's exam in Chemistry which he had sent to the Department of Education. One of the most interesting forms of teacher reaction was that of feeling that they were perhaps teaching to the examination too much, and that the exam did constrain their teaching somewhat. All teachers felt an obligation to ensure that the core material to be tested was covered. In fact, most treated this as an essential defining feature of their jobs, a point to which we shall return. Beyond this, teacher reasons for teaching to the exam varied. Some argued that this is what students, parents, and school system officials expected, and that the teacher's job is to do what is expected. For others, the exams are a natural final outcome of teaching, and no qualms were expressed about the system or the exam content. Though there is no formal scheme for calling teachers to account for poor performance on the part of students, a number of teachers did feel that this was an inherent part of the basis on which they were judged. While teachers were not asked explicitly how they would feel if the exams did not exist, there was a distinct impression that teachers are well socialized to the system and that they take it as given that they will act so as to ensure that student performance in the exams is maximized.

Overall, then, while the public examinations were ever-present in the thinking of teachers and students, and in the evaluation program as a whole, this presence was not found to have extreme manifestations in such things as coaching for the exams. Concern with the exams seems to be a natural element in classroom activity, and is taken as part of the normal business of the classroom. In fact, one might go further and argue that the exams are a fundamental element in the system. Exams are problematic only to the extent that students may have difficulty passing or that teachers may be called to account for not having their students perform well.

**Unit Tests**

If public examinations represent the ultimate severance pay from schooling, unit tests constitute the monthly paycheques. More precisely, it

is the grades on such tests which yield the short term payoff from the work of the classroom. Beyond this, reviewing for such tests, conducting the test themselves, and "going over" the test after they are graded occupies a significant proportion of total classroom time. Unit tests are among the most important cyclic events in the life of classrooms. Unlike the public examinations, which show their influence mainly in the final year, unit tests and the like are prevalent at both the levels studied.

Virtually all curriculum packages are divided into units that are more or less self-contained. The science subjects observed in our studies were no exception. Textbook chapters or chapter clusters formed the most prominent dividing points. In some courses, such as physics and chemistry, in fact, separate books were used in the different units. These served to create sharp dividing points between units. One of the few areas in which teachers felt it within their prerogative to change the prescribed curriculum was, in fact, in the order in which these units were treated, a point which attests to the relative independence of the units. The important point here is that these units formed the basis for establishing times for unit tests.

The testing process itself followed a predictable sequence. As the end of the unit neared (usually following four to six weeks of instruction), the teacher would begin the process by announcing a date for the test. What followed varied in detail but, at a minimum, can be characterized by increased references to the test on the part of both teacher and students, attempts by students to find out as much as possible about what would be on the test, and some form review, either formal or informal. The tests themselves were constructed by the individual teacher (sometimes by the group of teachers in the same subject), and usually were presented to students in handwritten form. Item types varied, with the most frequent being either filling in blanks (for definitions, terminology and the like) or problem solving. Interestingly, multiple choice items were rare, even though this is the most common form in large scale testing programs (though not in the local public examinations).

Tests were always written within one class period, and were handed in to the teacher for marking. What happened next depended in an important way on whether or not the teacher managed to complete the marking quickly. If so, the next class period was almost exclusively devoted to a

post mortem on the test, with the teacher conducting a walk through the test giving correct answers and pointing out problem areas. If the test was not marked by the next day, students tended to show curiosity as to when the grades would be available and on how they did on the test. The teacher was placed in a defensive mode at this stage, frequently going to some length to explain why the test had not yet been marked. Clearly, there was substantial pressure on the teacher to complete the marking promptly. It is significant also that teachers went to some length to ensure that students were given an opportunity to point out errors in the grading. Comments such as "if you feel that I gypped you on a mark, see me after class" were typical, and give a direct indication of the concept of grades as currency.

**Expectations**

One of the most interesting aspects of evaluation was that of the expectations of teachers concerning the grades received by particular students. The prevailing view was clearly that the teacher could tell early in the year how a student was going to perform, and that a student's grades could be expected to be consistent throughout the year. One teacher went as far as to remark
that he could probably estimate a student's final grade after the first few weeks of the school year. Following from this, the main concern in looking at grades was whether students performed in a manner consistent with expectations.

While this would seem to give support to the Pygmalion effect concept, it should be emphasized that the study was not designed explicitly to explore this effect, and that there was no evidence that the expectancies expressed took the form of self-fulfilling prophecies. In fact, the nature of the unit tests and other evaluation devices used made it unlikely that teachers would grade individual papers on the basis of expectations. What is important, however, is that expectations could be used to justify particular levels of performance rather than used as a basis for taking steps to bring about improved performance.

**Marking and the use of Marks**

"Last year I marked exactly 12,287 lab reports." This rather plaintive comment by a teacher (probably more precise than accurate), sums up the pervasiveness of grading as an aspect of the teacher's work. While no quantitative estimates of time were obtained in this study, it is clear that grading occupies much more of the teacher's time than preparation or other developmental activities.

This is entirely in keeping, of course, with the emphasis on evaluation. More generally, it highlights the teacher's role as the dispenser of rewards, and the need to be able to justify the distribution of rewards on the basis of careful assessment of tests and other documentation produced by students. The importance of this
is further illustrated by the earlier discussion of activities following the completion and handing back of tests. Teachers were obviously expected to be able to justify the grades given, and students equally obviously looked to grades as the payoff for their efforts.

Teacher universally kept careful records of grades in what many called their "little black books." The record of grades was the primary reference when teachers were asked about the performance of students. It is interesting that little attention was paid to statistical analysis of grades, beyond such things as averaging a student's scores over a term for report card purposes. Even class averages were not widely used, despite the tendency of teachers to think of the performance of a class as a whole when discussing their teaching.

The need for careful record-keeping was closely linked to the procedures for awarding final grades, as these were a composite of all the grades received during the year. For Grade 12, in particular, the final grade awarded by the teacher was given equal weight with the external examination score for certification purposes. Thus, half a student's high school leaving grade in a subject was made up of a composite of many marks earned throughout the year, while the other half consisted of a score on a single examination. In other grades, similar procedures were in effect, though the final examinations being internal to the school.

**Discussion**

The elaborate evaluation apparatus used in high school science obviously says a great deal about what is done in the classroom and about how the teacher thinks about the job of teaching. The high stakes involved in the reward system places important constraints on what the teacher can do in translating the curriculum, and in carrying out particular classroom activities. In particular, evaluation itself becomes an important element of classroom life. Preparation for tests, writing these tests, and conducting the required post-mortems in themselves account for significant proportions of classroom time. Add to this the teacher's test making and marking time, and it is not difficult to see how the teacher's job is circumscribed to a considerable degree by the demands of evaluation. In fact, is seems to be no exaggeration to assert that the teacher's job is defined more by the need to attend to evaluation matters than by the need to engage in curriculum modification, development of presentation procedures, attending to individual students, or other elements of what teacher educators or others would consider important aspects of teaching.